Catch and Release Mortality Rates For Coho Salmon Captured on Motor-Mooched Cut-Plug Herring Near Work Channel, British Columbia, in 1998

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CATCH AND RELEASE MORTALITY RATES FOR COHO SALMON CAPTURED ON MOTOR-MOOCHED CUT-PLUG HERRING NEAR WORK CHANNEL, BRITISH COLUMBIA, IN 1998

by

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ABSTRACT

Cox-Rogers, S. 2004. Catch and release mortality rates for coho salmon captured on motor-mooched cut-plug herring near Work Channel, British Columbia, in 1998. Can. Manuscr. Rep. Fish. Aquat. Sci. 2677: vii+ 28 p.

This report documents short-term (0-24 hr) catch and release mortality rates for coho salmon captured in a recreational fishery using motor mooched cut-plug herring near Work Channel, British Columbia during September 1998. Professional sport fishing guides were contracted to do the fishing. A total of 242 coho were captured and held for observation. Single barbless hook baits accounted for 174 hookups, 79 losses, and 94 landings, for an overall landing rate of 54.0%. Tandem barbless hook baits accounted for 240 hookups, 92 losses, and 148 landings, for an overall landing rate of 61.7%. The fish were held for up to 24 hours in live-hold tanks aboard a specially equipped holding vessel. The mean short-term (0-24hr) mortality rate for coho captured on single barbless hooks was 25.5% (95% c.l. 14.7% - 36.3%). The mean short-term (0-24hr) mortality rate for coho captured on tandem barbless hooks was 25.7% (95% c.l. 15.6% - 35.8%). Hook location was found to be the major factor associated with hooking mortality. A high proportion of the fish that died were hooked in the deep mouth area, where hooking injuries to the various blood vessels and nerves associated with the throat, heart, and gill arches occurred.

RÉSUMÉ

Cox-Rogers, S. 2004. Catch and release mortality rates for coho salmon captured on motor-mooched cut-plug herring near Work Channel, British Columbia, in 1998. Can. Manuscr. Rep. Fish. Aquat. Sci. 2677: vii + 28 p.

Ce rapport documente à court terme (0-24 hr) les taux de mortalité de prise et relâchement pour le saumon de coho capturé dans une pêche divertissante utilisant l'hareng de coupure-bouchon de mooched moteur près de la Chaîne de Travail, Colombie Britannique pendant le 1998 septembre. Le sport professionnel pêchant des guides ont été contractés pour faire la pêche. Un total de 242 coho a été capturé et a été tenu pour l'observation. Les appâts seuls de crochet de barbless ont expliqué 174 connexions, 79 pertes, et 94 terres, pour un taux d'atterrissage général de 54.0%. En tandem les appâts de crochet de barbless ont expliqué 240 connexions, 92 pertes, et 148 terres, pour un taux d'atterrissage général de 61.7%. Le poisson a été tenu pour jusqu'à 24 heures dans les réservoirs de vie-prise à bord d'un spécialement équipé tenant le vaisseau. Le moyen à court terme (0-24hr) le taux de mortalité pour coho a capturé sur les crochets de barbless seuls était 25.5% (95% c.l. 14.7% - 36.3%). Le moyen à court terme (0-24hr) le taux de mortalité pour coho a capturé sur en tandem les crochets de barbless étaient 25.7% (95% c.l. 15.6% - 35.8%). L'emplacement de crochet a été trouvé pour être le facteur majeur associé avec accrocher de mortalité. Une haute proportion du poisson qui est mort a été accrochée dans le secteur de bouche profond, où accrochant des blessures aux divers vaisseaux sanguins et les divers nerfs associés avec la gorge, le coeur, et gill arquer arrivé.

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INTRODUCTION

Motor mooching is a popular method of fishing for coho along the northern mainland coast of British Columbia (Prince Rupert/Chatham Sound). Motor mooching involves fishing a head-off "cut-plug" herring using tidal currents and boat movement to impart action to the bait. Hook location for coho caught using the motor mooching method can vary depending upon the type and presentation of the bait, the type of strike, and the size and aggressiveness of the fish. As many coho may be caught and released by anglers during the course of a days fishing, particularly during coho non-retention fisheries, the mortality rates associated with motor mooching are of interest.

Various studies have documented catch and release mortality rates for both coho and chinook salmon caught using different angling methods (CTC 1997, Gjernes 1990, Gjernes et al 1993, Grover 1995a, NRC 1991, NRC 1994a). In each of these studies, hooking location was found to be the variable most associated with catch and release mortality. Mortality rates are higher when hooks are located deep in the mouth where injury to the various blood vessels and nerves associated with the throat, heart, and gill arch area can occur. Mortality rates are lower when hooks are located in the outer mouth and jaw area, where injury to the throat, heart, and gill arch area is less likely. In general, salmon caught using trolling techniques are often hooked in the outer mouth and jaw area, while salmon caught mooching are often hooked deeper in the mouth as a result of fish attempting to "swallow" the bait.

Although mooching can result in deep hooking, the method of bait presentation and the action of the bait is important when considering catch and release mortality rates. For example, in Washington State, initial studies on sport hooking mortality found a 6% mortality rate for coho taken with trolled cut-plug herring (NRC 1991). The same study found a 10% mortality rate for chinook salmon (held for 4 days) taken with a variety of methods, including mooching and flasher and lure trolling with downriggers. In a two year study in Oregon, short term mortality rates (i.e. 3 hours) of 3% to 24% were observed, depending upon the salmon species and the gear used (Doug McNair, Natural Resources Consultants Inc., 4055 21st Ave West, Seattle, Washington, pers. comm). Passive mooching, or "California" style mooching, where baits are still fished with no action imparted, results in coho mortality rates of 24% over the short term to probably greater than 50% over the long term as there is a high proportion of gullet hooking which typically take longer to make the fish die (Doug McNair, NRC, pers. comm.).

In British Columbia, the only mooching studies involving chinook and coho were at Langara Island in 1992 and 1993, where troll-mooched cut-plug herring resulted 15% and 10% mortality rates for chinook and coho respectively (Terry Gjernes, Fisheries and Oceans Canada, 3225 Stephenson Pt. Rd, Nanaimo, B.C. pers. comm.). Besides hook location, fish size can also be an important factor in determining catch and release mortality rates for salmon. Several studies have noted a tendency toward increased

mortality with increase fish size when mooching methods are used simply because larger fish are able to ingest baits deeper (Doug Mcnair, NRC, pers. comm.).

Given the range of mortality rates associated with catch and release fishing, it is important to determine the actual rates for specific sport fisheries. Currently in British Columbia, a 10% catch and release mortality rate is applied to marine sport fisheries for coho, independent of the angling method used (Terry Gjernes, DFO, pers. comm.). In 1998, Fisheries and Oceans Canada (DFO) severely restricted angling opportunities for coho in northern British Columbia to address conservation concerns for Upper Skeena River coho. Rather than implementing a complete sport fishing closure, barbless hook retention fisheries for all salmon species except coho were allowed in certain areas, assuming that catch and release mortality rates for coho would be in the 10% range. To test this assumption, DFO conducted a study of motor mooched coho using single and tandem barbless hook cut-plug herring in the outer Work Channel area north of Prince Rupert. This fishery is typical of August-October coho sport fisheries in the Prince Rupert/Chatham Sound region. This report documents the results, and presents several conclusions for management consideration.

METHODS

Assessment Approach

Catch and release mortality is measured by holding landed salmon in special live tanks or net pens for time periods as short as a few hours to as long as several days. The number of salmon that die during holding (delayed mortality) is added to the number of fish dead upon landing (immediate mortality) to estimate landed mortality (CTC 1997). For this study, landed mortalities are referred to as "short-term mortalities" because they were measured over a 24 hour period.

The number of salmon that escape the gear prior to landing and die because of the encounter (drop-off mortality) or die because of subsequent predation (associated mortality) constitutes non-landed mortality (CTC 1997). Most studies cannot estimate total non-landed mortality with any degree of accuracy, and so reported estimates of catch and release mortality from holding studies tend to underestimate the actual mortality rate associated with any fishing technique if holding bias is small. No attempt was made to establish estimates of non-landed mortality rates in this study.

Fish Capture

Three professional fishing guides were hired to capture coho for this study. Fishing was conducted for nine days in the outer portions of Work Channel (45 km north of the Skeena River estuary, Figure 1) during September 1998. Each of the guides were skilled in motor mooching techniques. Consideration was given to obtaining mooched

coho from anglers at large, but the general lack of salmon anglers fishing Prince Rupert waters during September 1998 precluded this approach.

Each guide provided their own fishing boat, rods, terminal tackle and bait. The boats were 6 to 7 meters long and were rigged for motor mooching with stand alone rod-holders, small auxiliary outboard motors, and tackle support. A fourth boat, a 4 meter hard hull Zodiac crewed by experienced volunteer anglers from DFO, was also used to catch coho during the course of the study.

Fishing occurred for three days (Mon-Wed) each week during the first three weeks of September 1998. Fishing began one to one and one half hours after daylight (0800-0830), and continued until early afternoon (1400-1500) each day. Each boat fished up to four individual rods; two rods rigged with single barbless hooks, and two rods rigged with two single (e.g. tandem) barbless hooks. Frozen medium herring (7 inch) were used as bait, fished head-off (cut-plug) on 4/0 "J" hooks. Hook placement was left to the discretion of the guides, but was found to be similar among boats (Figure 2). A minimum of two anglers fished aboard each boat at any given time, with the exception of the DFO boat, which often fished just two rods and had one angler aboard. A total of 15 different anglers participated in the study.

Herring baits were usually placed in a salt-brine solution for "firming" prior to use. The rods used were limber 10-10.5 ft mooching rods equipped with single action mooching reels spooled with 20-25lb test monofilament mainline. Leaders were tied on 15lb to 20lb test monofilament leader material, connected to the mainline with one or two stainless steel ballbearing swivels. Light sliding weights (4oz to 8 oz) were connected to the mainline above the swivel and leader system. Herring cut-plugs were checked for spiralling action close to the boat prior to being lowered into the water 10 to 25 "pulls", or 6 to 17 meters under the boat. The rods were placed in individual rod-holders adjusted to maintain the rods at an approximate 90 degree angle with the boat.

Bait action was maintained using the auxiliary motors to hold the boats relatively stationary to (or drifting slowly back with) the current when the tide was running. When currents were slack, bait action was maintained by deliberately trolling the baits through the water using forward movement of the boat. At various times, fast trolling of the baits was conducted in order to move the boat back into favoured positions. During these manoeuvres, the baits would often come to the surface and slowly sink back down as boat speed diminished. A preferred angle of 45 degrees or so was maintained on each line. Eddies and side currents off points close to shore were the preferred mooching locations. Tidal variations in the Work Channel Area were large and typical of tidal run out in the waters surrounding Prince Rupert (> 7 m).

Coho were hooked in one of two fashions. Aggressive strikes, characterized by a deep rod bend and line taken from the reel, required minimal angler attention other than a strong rod lift to "set" the hooks. Light strikes, characterized by the rod dipping or bouncing gently to indicate a coho mouthing the bait, required significant angler

attention, with anglers often waiting and feeding slack line (one or two "pulls") before winding quickly and striking to set the hooks. Hooked fish were played by one angler while other rods were boated to avoid tangling.

An activity log for each rod was kept on each boat to record the total number of strikes, hook-ups, losses and landings. Fish were alternatively landed by either dip netting and holding the fish at the side of the boat while the hook(s) were removed, or by tailing with a cotton glove and being held at the side of the boat while the hooks were removed. If the hook (s) was not visible or easily extracted because of deep hooking, leaders were cut and the hook (s) were left in the fish to avoid further injury. Landed fish were placed head first into special zippered fish bags and tethered head first to the stern of the boat to maintain water circulation prior to retrieval for holding. Data records kept by each angler upon landing each coho included the playing time, the landing method, the condition upon landing, the location of each hook (s), the degree of hook damage, the degree of bleeding, the degree of scale loss, and a fish tag number. Four general categories of hooking location were recorded:

Out: for tandem hooks where one of the two hooks was observed to be free of the fish upon landing. Hooks categorized as "out" may have torn free of the fish during playing, or may have been free of the fish prior to and after to hook-up.

Deep Mouth: for single or tandem hooks located in the throat/gill area, including hooks swallowed and lodged into the throat, lodged into the posterior portions of the roof or floor of the mouth, lodged into gill arches, or lodged under or into the posterior portions of the tongue. Hooks located in this area were not easily seen or easily removed by casual inspection, and were often left in the fish.

Outer Mouth: for single or tandem hooks located in the lip/jaw region, not including areas associated with the deep mouth region. Hooks located in this area were easily seen and easily removed by casual inspection.

Body/Head: for single or tandem hooks located outside of the Outer mouth and jaw area but including the outer head and body. Hooks in this area were easily seen and removed by casual inspection.

Fish Holding

Coho were held for observation aboard a specially equipped live-hold vessel contracted to DFO. One experienced live-hold technician was responsible for retrieving, transferring, holding, and monitoring all coho. A 3.5 meter Zodiac with a 300 litre water-circulating forward tank transported landed coho from the capture site to the live-hold vessel located in a small bay near the fishing site. Upon retrieval, each coho was removed from its holding bag, placed into the retrieval tank, tagged with a numbered Floy tag, and transported as quickly as possible (2-3 minutes) to the live-hold vessel. As many as three

or four coho were transported at one time using this approach. VHF radio contact was maintained between the live-hold vessel and the fishing vessels on the ground at all times.

Upon arrival at the live hold-vessel, each coho was measured, sexed, tissue (adipose punch) sampled for later DNA analysis, and transferred into one of six covered polyethylene tanks maintained on the aft deck. Each tank held 1230 litres of seawater when full. Water circulation to each tank was maintained by a gasoline pump drawing fresh seawater from a 10 cm diameter hose positioned 2 meters under the live-hold-vessel. A splitter bank transferred fresh seawater into the bottom of each circulating tank at a maximum rate of 165 litres per minute. Excess water flow was allowed to escape over the top of each tank. Oxygen diffusers, although not required during the study, were placed in the bottom of each circulating tank and hooked to a central oxygen supply for maintaining oxygen levels at ambient levels. Dissolved oxygen and water temperatures within each tank were monitored by the retrieval technician throughout the course of the study. A maximum of 5 coho per tank, or 30 coho per day, could be held aboard the live-hold vessel. Dead coho were removed from each tank as they were found. Coho were held in the tanks for periods of up to 24 hours. All coho were released from the live-hold vessel prior to commencement of the next days fishing.

RESULTS

Landing Rate by Hook Type

A total of 242 coho were landed and held for observation during this study. Landing rates were slightly higher for tandem barbless hooks than single barbless hooks (Figure 3). Single hook baits accounted for 174 hook-ups, 79 losses, and 94 landings, for an overall landing rate of 54.0% (Table 1). Tandem hook baits accounted for 240 hook-ups, 92 losses, and 148 landings, for an overall landing rate of 61.7% (Table 1). Although both hook-ups/rod-day and landings/rod-day were both higher for tandem hooks compared to single hooks, there was considerable daily variability in the landing rates for both hook types (Table 1). Several anglers commented on the variable responsiveness of coho to the gear from day to day, which may account for these results.

Mortality Rates by Hook Type

A total of 62 coho died during the course of this study. The mean short-term (0-24hr) mortality rate for coho caught on single hooks was 25.5% (95% c.l. 14.7% - 36.3%) (Figure 4, Table 2). The mean short-term (0-24hr) mortality rate for coho caught on tandem hooks was 25.7% (95% c.l. 15.6% - 35.8%) (Figure 4, Table 2). As with the landing rate observations, there was considerable daily variation in the short-term (0-24hr) mortality rates for both hook types from day to day (Table 2). Contrary to angler expectations, daily mortality rates were weakly correlated with daily landing rates for both single and tandem hooks (Table 3), suggesting that higher daily landing rates (e.g. more secure hook-ups) did not translate into higher daily mortalities.

Location of Hooks by Hook Type

a) Landings

The outer mouth was the most common hooking location for coho caught on both single and tandem hooks (Figure 5). Of the 94 coho caught on single hooks, 51.1% were hooked in the outer mouth area, 39.4% were hooked in the deep mouth area, and 9.6% were hooked in the body or head (Table 4). Of the 148 coho caught on tandem hooks, 47.9% had one or both hooks in the outer mouth area, 27.7% had one or both hooks in the deep mouth area, 17.6% had one or both hooks in the body/head area, and 6.8% had both hooks in various combinations of all three hooking areas (Table 5).

The lead and trailing hooks of the tandem pair were involved in about the same number of hook-ups (42.6% and 41.2% respectively, Figure 6, Table 6). Only 16.2% of the coho were hooked by both tandem hooks at the same time. Of the coho hooked by the lead hook alone, 60.3% were hooked in the outer mouth area, 22.2% were hooked in the deep mouth area, and 17.5% were hooked in the body/head area (Table 6). Of the coho hooked by the trailing hook alone, 49.2% were hooked in the outer mouth area, 29.5% were hooked in the deep mouth area, and 21.3% were hooked in the body/head area (Table 6). The majority of the coho hooked by both the leading and trailing hooks at the same were hooked in deep mouth area (Table 6).

b) Mortalities

While most coho were hooked in the outer mouth area, the holding observations suggest that those hooked in the deep mouth area were the ones most likely to die (Figure 7). For coho caught on single hooks, 54.0% of the fish hooked in the deep mouth area died, accounting for 83.3% of the total mortalities and 21.3% of the total landings (Table 4). Only 6.2% of the coho caught on single hooks in the outer mouth area died, accounting for just 12.5% of the total mortalities and 3.2% of the total landings (Table 4). Of the coho caught on single hooks in the body or head, 11% died, accounting for just 4.2% of the total mortalities and only 1.1% of the total landings (Table 4). Daily mortality rates were positively correlated with the proportion of daily landings hooked in the deep mouth for both single and tandem hooks (Table 3)

For coho caught on tandem hooks, 63.4% of the fish hooked by one or both tandem hooks in the deep mouth area died, accounting for 68.5% of the total mortalities or 17.6% of the total landings (Table 5). Only 14.1% of the fish hooked by one or both tandem hooks in the outer mouth area died, accounting for 26.3% of the total mortalities or 6.8% of the total landings (Table 5). No fish died as a result of being hooked in the body or head by one or both tandem hooks, but 20% of the coho hooked by both hooks together in a combination of hooking areas died, accounting for 5.2% of the total mortalities, or 1.4% of the total landings (Table 5).

The proportion of mortalities attributable to at least one of the tandem hooks in the outer mouth area (26.3%) was more than double the proportion of mortalities attributable to a single hook in the outer mouth area (12.5%). It's possible that hooking injuries caused by a free tandem hook, either by tearing out of an initial hooking location, or by injuring the fish from outside of the mouth during playing, might explain these results. Lethal injuries caused by free hooks have been reported (Doug McNair, NRC, pers comm.).

The lead and trailing hooks of the tandem pair were involved in a similar number of mortalities: 34.2% of the coho that died were hooked by the lead hook alone while 39.5% of the coho that died were hooked by the trailing hook alone (Figure 8, Table 6). Well over one quarter (26.3%) of the coho that died were hooked by both tandem hooks at the same time. Of the coho hooked by the lead hook alone that died, 61.5% were hooked in the deep mouth area, 38.4% were hooked in the outer mouth area and 0% were hooked in the body/head area (Table 6). Of the coho hooked by the trailing hook alone that died, 66.6% were hooked in the deep mouth area, 33.3% were hooked in the outer mouth area and 0% were hooked in the body/head area (Table 6). Of the coho that died hooked by both the leading and trailing hooks at the same time, the majority were hooked in deep mouth area (Table 6).

Bleeding Rates by Hook Type

Bleeding from the mouth or gill area was observed in 23.4% of the coho caught on single hooks, and in 27.7% of the coho caught on tandem hooks (Figure 9, Tables 7 and 8). Bleeding upon landing was categorized as being either major or minor. No attempt was made to identify the exact source of the bleeding. For coho caught on single hooks, 59.1% of the bleeders were hooked in the deep mouth and exhibited major bleeding (Table 7). For coho caught on tandem hooks, 68.3% of the bleeders were hooked in the deep mouth and exhibited major bleeding (Table 8). The majority of the coho hooked in the outer mouth that were classified as bleeders (31.8% for single hooks, 21.9% for tandem hooks, Tables 7 and 8) exhibited minor bleeding.

Bleeding from the mouth and gill area was associated with hooking mortality. Bleeders accounted for 41.7% of the mortalities for coho hooked on single hooks, and 55.3% of the coho hooked on tandem hooks (Figure 10, Table 7 and 8). Almost all of the bleeding fish that died were those that had also been hooked in the deep mouth area (80% for single hooks, 100% for tandem hooks, Tables 7 and 8). However, not all of the coho that exhibited bleeding upon landing died during holding, which suggests that coho can recover from hook related bleeding wounds (Tables 7 and 8).

Scale Loss By Hook Type

There was no evidence that scale loss was an important factor in determining catch and release mortality rates for this study. Of the 94 coho caught on single hooks, 6.4% exhibited minor scale loss (Table 9). Of the 148 coho caught on tandem hooks,

12.8% exhibited minor scale loss (Table 10). For single hooked fish, 66% of the scaled fish eventually died, while, for tandem hooked fish, 42.1% of the scaled fish eventually died (Tables 9 and 10). Almost all of the scaled fish that died were those that had also been hooked in the deep mouth area, and so the importance of scale loss in determining eventual death was difficult to establish.

Length Frequencies by Hook Type

There was no significant difference ($p>0.05$) between the mean nose-fork lengths of coho landed on single hooks (70.1 cm) or tandem hooks (69.8 cm), nor was their a significant difference ($p>0.05$) between the mean nose-fork lengths of the coho that died after being landed on single hooks (71.7 cm) or tandem hooks (69.6 cm) (Tables 11 and 12). Several coho measuring greater than 85 cm (nose-fork) were landed during the course of the study (Table 12).

Frequency of Holding Times by Hook Type

Of the 70 coho caught on single hooks that survived, the mean holding time was 18.3 hours, while of the 24 coho caught on single hooks that died, the mean holding time was 3.4 hours (Table 13). Of the 100 coho caught on tandem hooks that survived, the mean holding time was 19.3 hours, while of the 38 coho caught on tandem hooks that died, the mean holding time was 5.3 hours (Table 13). The holding times for fish that died may be somewhat inflated, as dead fish were removed from the holding tanks when first noticed, rather than when they may actually have died.

Frequency of Playing Times by Hook Type

Of the 70 coho caught on single hooks that survived, the mean playing time was 5.1 minutes, which was the same as the mean playing time for the 24 coho caught on single hooks that died (Table 14). Of the 110 coho caught on tandem hooks that survived, the mean playing time was 5.6 minutes, which was essentially the same as the mean playing time for the 38 coho caught on tandem hooks that died (Table 14). The longest playing times recorded were some for coho hooked outside of the mouth in the body or head (10 minutes or longer).

DISCUSSION

The purpose of this study was to determine catch and release (short-term 0-24hr) mortality rates for coho caught using motor mooched cut-plug herring in the Work Channel area north of Prince Rupert. Short-term (0-24hr) mortality rates are in the 26% range for this fishery using cut-plug herring rigged on either single barbless hooks (25.6%: 95% c.l. 14.7% - 36.3%) or tandem barbless hooks (25.7%: 95% c.l. 15.6% - 35.8%). These rates are higher than those reported for coho caught on trolled cut-plug herring (6% to 10%, NRC 1991, Terry Gjernes, DFO, pers comm.) but lower than those

reported for coho caught on "still" mooched cut-plug herring (24% to >50%, Doug McNair, NRC, pers comm.). Motor mooching incorporates both slow trolling and "still" fishing techniques, which may explain these results.

The actual causes of death for coho held in this study were not determined, but would include a) physiological stress associated with playing, handling, and holding, and b) physical injury associated with hooking wounds, nerve damage, blood loss, and scale loss. Quantifying the effect of physiological stress was beyond the scope of this study, but the holding observations show that most of the fish with minor physical hooking injuries survived, suggesting that stress factors were probably of minor importance. In contrast, the holding observations show that many of fish with major physical hooking injuries died, suggesting that physical injury is very important.

For example, short-term (0-24hr) mortality rates are highest for coho hooked in the deep mouth area, where physical injury to the various nerves and blood vessels associated with the throat, heart, and gill arch area can occur. While the majority of coho captured on both single and tandem hooks were hooked in the outer mouth area, motor mooching results in a substantial proportion of coho hooked in the deep mouth area because many fish attempt to swallow the bait. For coho caught on single hooks, 39.4% were hooked in the deep mouth area: 54.0% of these fish eventually died, accounting for 83.3% of the total mortalities, or 21.3% of the total landings. For coho caught on tandem hooks in this study, 27.7% were hooked by at least one hook in the deep mouth area: 63.4% of these fish eventually died, accounting for 68.5% of the total mortalities, or 17.6% of the total landings.

Short-term (0-24hr) mortality is also associated with the incidence of bleeding caused by hooking injuries to the deep mouth area. Bleeding occurred in 23.4% of the coho captured on single hooks, and in 27.7% of the coho captured on tandem hooks. For coho caught on single hooks, 59.1% of the bleeders were hooked in the deep mouth and exhibited major bleeding. For coho caught on tandem hooks, 68.3% of the bleeders were hooked in the deep mouth and exhibited major bleeding. Bleeders accounted for 41.7% of the mortalities for coho hooked on single hooks, and 55.3% of the mortalities for coho hooked on tandem hooks. However, not all of the coho that exhibited bleeding upon landing died during holding, which suggests that coho can recover from hook related bleeding wounds.

Scale loss was not a factor in determining short-term (0-24hr) mortality rates for this study. Although scale loss is associated with coho mortality (NRC 1991, Jim Thomas, J.O. Thomas and Associates, 1370 Kootenay St. Vancouver, B.C. pers comm.), the fish handled in this study exhibited minimal scale loss, probably because of the careful handling procedures used. Only 6.4% of the coho caught on single hooks exhibited scale loss, while only 12.8% of the coho caught on tandem hooks exhibited scale loss. Scale loss could be important in the general sport fishery, where many coho are netted and actually brought into the boat prior to release.

The similar mortality rates for coho caught on single and tandem barbless hooks was somewhat surprising. Single barbless hooks were expected to result in lower mortality rates compared to tandem barbless hooks given that only one hook is involved (one less hook, easier to remove, etc.). However this would only be true if single hooks caused less hooking injury than tandem hooks when located in the deep mouth area, or if single hooks are located in the outer mouth area more often than tandem hooks. The data show that single hooks are actually present in the deep mouth area more often than one or both tandem hooks (39.4% and 27.7% of the landings respectively), probably because single hooks hang up in the outer mouth less often than tandem hooks when coho attempt to "swallow" the cut-plug. Fish size may also be important, as larger coho, typical of those caught in this study, can simply ingest cut-plug baits into the deep mouth area more easily than smaller coho, regardless of whether one or two hooks are used (Doug McNair, NRC, pers comm.).

Hook placement and hook type may influence short-term (0-24hr) mortality rates for motor mooched cut-plug herring. The hook placements and sizes (4/0) tested in this study were those commonly used by anglers in the Prince Rupert/Chatham Sound area; for tandem rigs, the lead hook is placed in or near the bevel of the herring, while the trailing hook is placed near the tail. Single hooks are threaded through the bevel of the herring and placed near the tail. Other hook placements, such as having a single hook nearer the bevel of the herring, have been suggested assuming that coho taking baits tail first would not ingest a top-rigged hook deeply. However, the data for tandem hooks suggest that baits are taken both head and tail first, as there is little difference in the number of landings and mortalities attributable to the lead and trailing hooks located in the deep mouth area. These results are contrary to other studies which show that trailing hooks near the tail of the herring are often responsible for the majority of injuries and mortalities associated with the injuries to the deep mouth area (NRC 1991). One area of further study would be to test the use of different hook types (e.g. circle hooks) to see if hooking locations, and thus mortalities, can be controlled.

CONCLUSIONS

Motor mooching for coho with cut-plug herring in the Work Channel area north of Prince Rupert results in a relatively high (26%) short-term (0-24hr) catch and release mortality rate, independent of whether single or tandem barbless hooks are used. This value is substantially higher than the 10% catch and release mortality rate currently applied by DFO to this fishery. The motor mooching method of bait presentation is associated with high catch and release mortality rates primarily because of hooking injuries to the deep mouth area resulting from coho attempting to swallow the baits. Its unclear if more purposeful trolling of motor mooched baits in the Prince Rupert/Chatham Sound area would result in lower mortality rates for coho, as is suggested by other studies (NRC 1991, Terry Gjernes, DFO, pers comm.). The results of this study represent controlled assessment under specific landing, handling, and holding conditions; catch and

release mortality rates for the general motor mooching sport fishery in the Prince Rupert/Chatham Sound area could actually be higher than reported here.

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Table 1. Landing rates (landings/hook-ups) for coho caught on single barbless and tandem barbless hook cut-plug herring.

Hook Type	Date	# of rods	Strikes	Hookups	Losses	Landings	Hookups/ Rod-Day	Landings/ Rod-Day	Landing Rate (1)
Single	7/9/98	4	18	12	5	7	3.00	1.75	58.3%
"	8/9/98	4	30	21	9	12	5.25	3.00	57.1%
"	9/9/98	3	29	22	9	13	7.33	4.33	59.1%
"	14/09/98	4	26	19	8	11	4.75	2.75	57.9%
"	15/09/98	4	17	15	8	7	3.75	1.75	46.7%
"	16/09/98	4	20	18	6	12	4.50	3.00	66.7%
"	21/09/98	5	31	28	19	8	5.60	1.60	28.6%
"	22/09/98	5	27	23	11	12	4.60	2.40	52.2%
"	23/09/98	5	27	16	4	12	3.20	2.40	75.0%
	Total	38	225	174	79	94	4.58	2.47	54.0%
Tandem	7/9/98	5	33	30	10	20	6.00	4.00	66.7%
"	8/9/98	5	59	42	20	22	8.40	4.40	52.4%
"	9/9/98	4	38	20	6	14	5.00	3.50	70.0%
"	14/09/98	4	30	26	6	20	6.50	5.00	76.9%
"	15/09/98	4	24	16	7	9	4.00	2.25	56.3%
"	16/09/98	4	30	22	5	17	5.50	4.25	77.3%
"	21/09/98	5	46	41	25	16	8.20	3.20	39.0%
"	22/09/98	5	26	22	7	15	4.40	3.00	68.2%
"	23/09/98	5	23	21	6	15	4.20	3.00	71.4%
	Total	41	309	240	92	148	5.85	3.61	61.7%
All	7/9/98	9	51	42	15	27	4.67	3.00	64.3%
"	8/9/98	9	89	63	29	34	7.00	3.78	54.0%
"	9/9/98	7	67	42	15	27	6.00	3.86	64.3%
"	14/09/98	8	56	45	14	31	5.63	3.88	68.9%
"	15/09/98	8	41	31	15	16	3.88	2.00	51.6%
"	16/09/98	8	50	40	11	29	5.00	3.63	72.5%
"	21/09/98	10	77	69	44	24	6.90	2.40	34.8%
"	22/09/98	10	53	45	18	27	4.50	2.70	60.0%
"	23/09/98	10	50	37	10	27	3.70	2.70	73.0%
	Total	79	534	414	171	242	5.24	3.06	58.5%

1) Landing Rate = Landings/Hookups*100

Table 2. Short-term (0-24hr) mortality rates for coho caught on single barbless and tandem barbless hook cut-plug herring (with 95% confidence interval).

Hook Type	Date	# of Landings	# of Mortalities	Mortality Rate (1)	lower 95% c.l..	upper 95% c.l.
Single	7/9/98	7	4	57.1%		
"	8/9/98	12	2	16.7%		
"	9/9/98	13	3	23.1%		
"	14/09/98	11	2	18.2%		
"	15/09/98	7	0	0.0%		
"	16/09/98	12	5	41.7%		
"	21/09/98	8	2	25.0%		
"	22/09/98	12	4	33.3%		
"	23/09/98	12	2	16.7%		
	Total	94	24	25.5%		
	Mean/Day	10.4	2.7	25.5%	14.7%	36.3%
	s	2.4	1.5			
	n	9	9			
Tandem	7/9/98	20	9	45.0%		
"	8/9/98	22	7	31.8%		
"	9/9/98	14	4	28.6%		
"	14/09/98	20	4	20.0%		
"	15/09/98	9	0	0.0%		
"	16/09/98	17	3	17.6%		
"	21/09/98	16	2	12.5%		
"	22/09/98	15	7	46.7%		
"	23/09/98	15	2	13.3%		
	Total	148	38	25.7%		
	Mean/Day	16.4	4.2	25.7%	15.6%	35.8%
	s	3.9	2.9			
	n	9	9			
All	7/9/98	27	13	48.1%		
"	8/9/98	34	9	26.5%		
"	9/9/98	27	7	25.9%		
"	14/09/98	31	6	19.4%		
"	15/09/98	16	0	0.0%		
"	16/09/98	29	8	27.6%		
"	21/09/98	24	4	16.7%		
"	22/09/98	27	11	40.7%		
"	23/09/98	27	4	14.8%		
	Total	242	62	25.6%		
	Mean/Day	26.9	6.9	25.6%	16.3%	34.9%
	s	5.0	4.0			
	n	9	9			

1) Mortality Rate = # of Mortalities/ # of Landings*100

Table 3. Pearson correlation coefficients for daily landing rates, daily mortality rates, and daily proportions of landings by hook location for coho caught on single barbless and tandem barbless hook cut-plug herring.

Single Hooks	Landing Rate	Mortality Rate	Deep Mouth	Outer Mouth	Body/Head
Landing Rate	1.000				
Mortality Rate	0.157	1.000			
Deep Mouth	-0.001	0.453	1.000		
Outer Mouth	0.089	-0.321	-0.905	1.000	
Body/Head	-0.211	-0.179	0.072	-0.489	1.000
Tandem Hooks	**Landing Rate**	**Mortality Rate**	**Deep Mouth**	**Outer Mouth**	**Body/Head**
Landing Rate	1.000				
Mortality Rate	0.205	1.000			
Deep Mouth	-0.009	0.665	1.000		
Outer Mouth	0.242	-0.357	-0.722	1.000	
Body/Head	-0.342	-0.587	-0.687	-0.007	1.000

Table 4. Summary location of hooks in the landings and mortalities for coho caught on single barbless hook cut-plug herring.

Hook Location	# of Landings	% of Total Landings	# of Mortalities	% of Total Mortalities	Mortalities as % of Total Landings
Out	0	0.0%	0	0.0%	0.0%
Deep Mouth	37	39.4%	20	83.3%	21.3%
Outer Mouth	48	51.1%	3	12.5%	3.2%
Body/Head	9	9.6%	1	4.2%	1.1%
Total	94	100.0%	24	100.0%	25.5%

Table 5. Summary location of hooks in the landings and mortalities for coho caught on tandem barbless hook cut-plug herring.

Hook Location	# of Landings	% of Total Landings	# of Mortalities	% of Total Mortalities	Mortalities as % of Total Landings
Both Out	0	0.0%	0	0.0%	0.0%
One in Deep Mouth	32	21.6%	18	47.4%	12.2%
Both in Deep Mouth	9	6.1%	8	21.1%	5.4%
One in Outer Mouth	68	45.9%	10	26.3%	6.8%
Both in Outer Mouth	3	2.0%	0	0.0%	0.0%
One in Body/Head	24	16.2%	0	0.0%	0.0%
Both in Body/Head	2	1.4%	0	0.0%	0.0%
Deep Mouth+Outer Mouth	5	3.4%	1	2.6%	0.7%
Deep Mouth + Body/Head	1	0.7%	0	0.0%	0.0%
Outer Mouth + Body/Head	4	2.7%	1	2.6%	0.7%
Total	148	100.0%	38	100.0%	25.7%

Table 6. Paired location of hooks in the landings and mortalities for coho caught on tandem barbless hook cut-plug herring.

# of Landings	Hook Location	Lead Out	Lead Deep Mouth	Lead Outer Mouth	Lead Body/Head	Total
Trailer	Out	0	14	38	11	63
Trailer	Deep Mouth	18	9	4	1	32
Trailer	Outer Mouth	30	1	3	1	35
Trailer	Body/Head	13	0	3	2	18
	Total	61	24	48	15	148

# of Mortalities	Hook Location	Lead Out	Lead Deep Mouth	Lead Outer Mouth	Lead Body/Head	Total
Trailer	Out	0	8	5	0	13
Trailer	Deep Mouth	10	8	1	0	19
Trailer	Outer Mouth	5	0	0	1	6
Trailer	Body/Head	0	0	0	0	0
	Total	15	16	6	1	38

% of Landings	Hook Location	Lead Out	Lead Deep Mouth	Lead Outer Mouth	Lead Body/Head	Total
Trailer	Out	0.0%	9.5%	25.7%	7.4%	42.6%
Trailer	Deep Mouth	12.2%	6.1%	2.7%	0.7%	21.6%
Trailer	Outer Mouth	20.3%	0.7%	2.0%	0.7%	23.6%
Trailer	Body/Head	8.8%	0.0%	2.0%	1.4%	12.2%
	Total	41.2%	16.2%	32.4%	10.1%	100.0%

% of Mortalities	Hook Location	Lead Out	Lead Deep Mouth	Lead Outer Mouth	Lead Body/Head	Total
Trailer	Out	0.0%	21.1%	13.2%	0.0%	34.2%
Trailer	Deep Mouth	26.3%	21.1%	2.6%	0.0%	50.0%
Trailer	Outer Mouth	13.2%	0.0%	0.0%	2.6%	15.8%
Trailer	Body/Head	0.0%	0.0%	0.0%	0.0%	0.0%
	Total	39.5%	42.1%	15.8%	2.6%	100.0%

Table 7. Bleeding rates in the landings and mortalities for coho caught on single barbless hook cut-plug herring.

Hook Location	# of Landings	# of Bleeders	% by Hook Location	% in Total Landings	# of Mortalities	# of Bleeders	% by Hook Location	% in Total Mortalities
Out	0	0	0.0%	0	0	0	0.0%	0.0%
Deep Mouth	37	13	59.1%	13.8%	20	8	80.0%	33.3%
Outer Mouth	48	7	31.8%	7.4%	3	1	10.0%	4.2%
Body/Head	9	2	9.1%	2.1%	1	1	10.0%	4.2%
Total	94	22	100.0%	23.4%	24	10	100.0%	41.7%

Table 8. Bleeding rates in the landings and mortalities for coho caught on tandem barbless hook cut-plug herring.

Hook Location	# of Landings	# of Bleeders	% by Hook Location	% in Total Landings	# of Mortalities	# of Bleeders	% by Hook Location	% in Total Mortalities
Both Out	0	0	0.0%	0.0%	0	0	0.0%	0.0%
One in Deep Mouth	32	20	48.8%	13.5%	18	15	71.4%	39.5%
Both in Deep Mouth	9	7	17.1%	4.7%	8	6	28.6%	15.8%
One in Outer Mouth	68	6	14.6%	4.1%	10	0	0.0%	0.0%
Both in Outer Mouth	3	3	7.3%	2.0%	0	0	0.0%	0.0%
One in Body/Head	24	4	9.8%	2.7%	0	0	0.0%	0.0%
Both in Body/Head	2	0	0.0%	0.0%	0	0	0.0%	0.0%
Deep Mouth+Outer Mouth	5	0	0.0%	0.0%	1	0	0.0%	0.0%
Deep Mouth + Body/Head	1	1	2.4%	0.7%	0	0	0.0%	0.0%
Outer Mouth + Body/Head	4	0	0.0%	0.0%	1	0	0.0%	0.0%
Total	148	41	100.0%	27.7%	38	21	100.0%	55.3%

Table 9. Scaling rates in the landings and mortalities for coho caught on single barbless hook cut-plug herring.

Hook Location	# of Landings	# Scaled	% by Hook Location	% in Total Landings	# of Mortalities	# Scaled	% by Hook Location	% in Total Mortalities
Out	0	0	0.0%	0	0	0	0.0%	0.0%
Deep Mouth	37	4	66.7%	4.3%	20	4	100.0%	16.7%
Outer Mouth	48	2	33.3%	2.1%	3	0	0.0%	0.0%
Body/Head	9	0	0.0%	0.0%	1	0	0.0%	0.0%
Total	94	6	100.0%	6.4%	24	4	100.0%	16.7%

Table 10. Scaling rates in the landings and mortalities for coho caught on tandem barbless hook cut-plug herring.

Hook Location	# of Landings	# Scaled	% by Hook Location	% in Total Landings	# of Mortalities	# Scaled	% by Hook Location	% in Total Mortalities
Both Out	0	0	0.0%	0.0%	0	0	0.0%	0.0%
One in Deep Mouth	32	7	36.8%	4.7%	18	5	62.5%	13.2%
Both in Deep Mouth	9	2	10.5%	1.4%	8	2	25.0%	5.3%
One in Outer Mouth	68	7	36.8%	4.7%	10	1	12.5%	2.6%
Both in Outer Mouth	3	0	0.0%	0.0%	0	0	0.0%	0.0%
One in Body/Head	24	3	15.8%	2.0%	0	0	0.0%	0.0%
Both in Body/Head	2	0	0.0%	0.0%	0	0	0.0%	0.0%
Deep Mouth+Outer Mouth	5	0	0.0%	0.0%	1	0	0.0%	0.0%
Deep Mouth + Body/Head	1	0	0.0%	0.0%	0	0	0.0%	0.0%
Outer Mouth + Body/Head	4	0	0.0%	0.0%	1	0	0.0%	0.0%
Total	148	19	100.0%	12.8%	38	8	100.0%	21.1%

Table 11. Length frequencies (nose-fork) in the landings and mortalities for coho caught on single barbless hook cut-plug herring.

Length Interval (cm)	Length Frequency of Landings	%	Length Frequency of Mortalities	%
46-50	2	2.1%	0	0.0%
51-55	1	1.1%	0	0.0%
56-60	6	6.4%	2	8.3%
61-65	14	14.9%	1	4.2%
66-70	26	27.7%	8	33.3%
71-75	27	28.7%	8	33.3%
76-80	10	10.6%	3	12.5%
81-85	8	8.5%	2	8.3%
86-90	0	0.0%	0	0.0%
91-95	0	0.0%	0	0.0%
96-100	0	0.0%	0	0.0%
Total	94	100.0%	24	100.0%
Mean Length (cm)	70.13			71.67
s	7.16			6.03
n	94			24

Table 12. Length frequencies in the landings and mortalities for coho caught on tandem barbless hook cut-plug herring.

Length Interval (cm)	Length Frequency of Landings	%	Length Frequency of Mortalities	%
46-50	6	4.1%	4	10.5%
51-55	3	2.0%	0	0.0%
56-60	11	7.4%	1	2.6%
61-65	26	17.6%	7	18.4%
66-70	34	23.0%	11	28.9%
71-75	27	18.2%	4	10.5%
76-80	22	14.9%	6	15.8%
81-85	16	10.8%	2	5.3%
86-90	2	1.4%	2	5.3%
91-95	1	0.7%	1	2.6%
96-100	0	0.0%	0	0.0%
Total	148	100.0%	38	100.0%
Mean Length (cm)	69.80			69.63
s	9.76			11.62
n	148			38

Table 13. Holding times for coho caught on single barbless and tandem barbless hook cut-plug herring.

Holding Time (hrs)	Single Hook Survivors	%	Single Hook Mortalities	%	Tandem Hook Survivors	%	Tandem Hook Mortalities	%
0	0	0.0%	2	8.3%	0	0.0%	3	7.9%
2	0	0.0%	5	20.8%	0	0.0%	6	15.8%
4	1	1.4%	8	33.3%	0	0.0%	10	26.3%
6	0	0.0%	6	25.0%	1	0.9%	11	28.9%
8	2	2.9%	2	8.3%	1	0.9%	3	7.9%
10	0	0.0%	1	4.2%	0	0.0%	1	2.6%
12	0	0.0%	0	0.0%	0	0.0%	0	0.0%
14	2	2.9%	0	0.0%	0	0.0%	0	0.0%
16	4	5.7%	0	0.0%	2	1.8%	0	0.0%
18	27	38.6%	0	0.0%	28	25.5%	1	2.6%
20	10	14.3%	0	0.0%	30	27.3%	1	2.6%
22	16	22.9%	0	0.0%	37	33.6%	1	2.6%
24	8	11.4%	0	0.0%	11	10.0%	1	2.6%
Total	70	100.0%	24	100.0%	110	100.0%	38	100.0%
Mean Time (hrs)	18.33		3.44		19.31		5.32	
s	3.65		2.17		2.71		5.61	
n	70		24		110		38	

Table 14. Playing times for coho caught on single barbless and tandem barbless hook cut-plug herring.

Playing Time (min)	Single Hook Survivors	%	Single Hook Mortalities	%	Tandem Hook Survivors	%	Tandem Hook Mortalities	%
0	0	0.0%	0	0.0%	0	0.0%	0	0.0%
1	1	1.4%	1	4.2%	1	0.9%	0	0.0%
2	5	7.1%	3	12.5%	5	4.5%	2	5.3%
3	11	15.7%	0	0.0%	13	11.8%	3	7.9%
4	7	10.0%	2	8.3%	9	8.2%	5	13.2%
5	29	41.4%	10	41.7%	46	41.8%	19	50.0%
6	3	4.3%	2	8.3%	5	4.5%	3	7.9%
7	5	7.1%	4	16.7%	12	10.9%	2	5.3%
8	1	1.4%	1	4.2%	5	4.5%	0	0.0%
9	0	0.0%	0	0.0%	1	0.9%	0	0.0%
10	8	11.4%	1	4.2%	10	9.1%	4	10.5%
11	0	0.0%	0	0.0%	0	0.0%	0	0.0%
12	0	0.0%	0	0.0%	3	2.7%	0	0.0%
Total	70	100.0%	24	100.0%	110	100.0%	38	100.0%
Mean Time (hrs)	5.11		5.13		5.65		5.26	
s	2.23		2.17		2.51		1.97	
n	70		94		110		38	

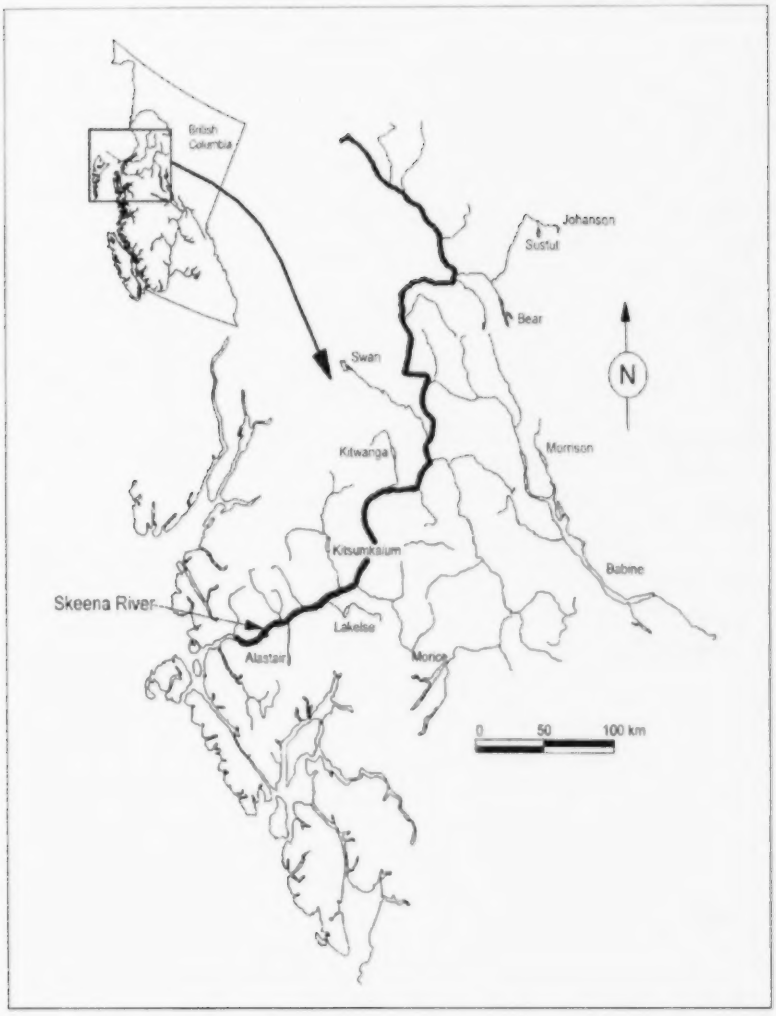

Figure 1. Study location. Work Channel is 45km due north of the Skeena River estuary in northern British Columbia.

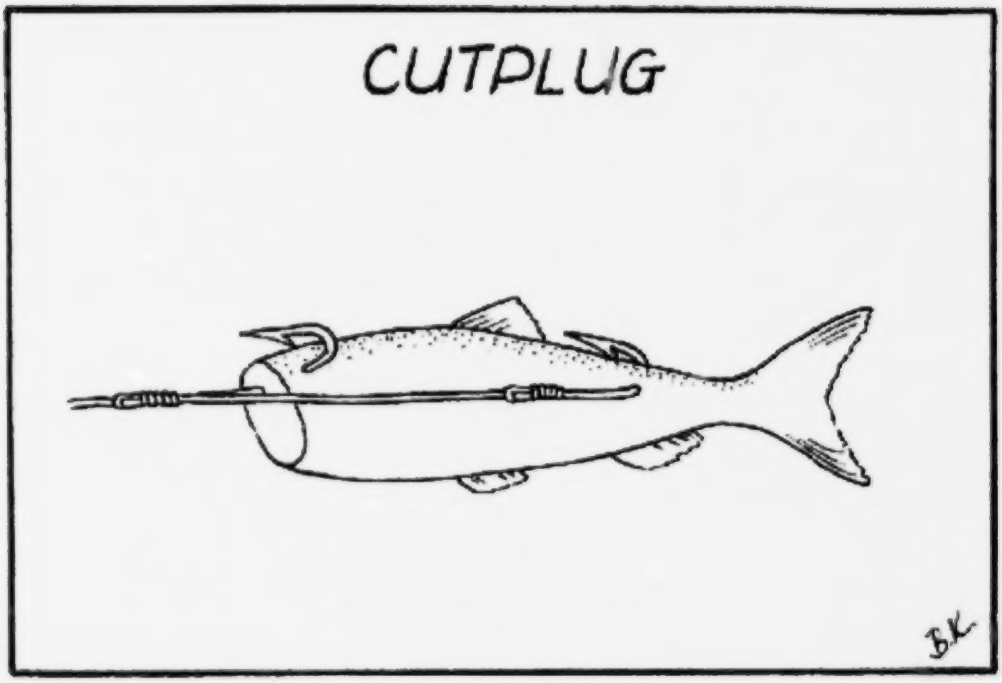

Figure 2. Basic terminal hook-up for tandem barbless hook cut-plug herring used in the study. Barbs were pinched down on all hooks. The terminal hook-up for single barbless hook cut-plug herring excluded the lead hook.

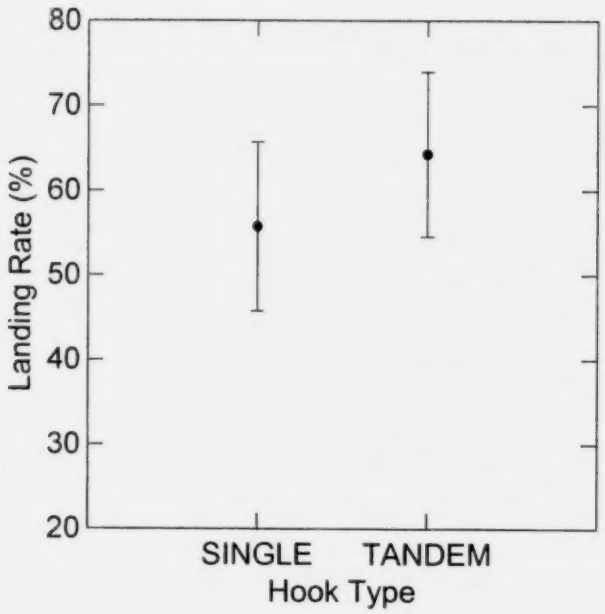

Figure 3. Mean landing rates (landings/hook-ups) for coho caught on single barbless and tandem barbless hook cut-plug herring (with 95% confidence interval).

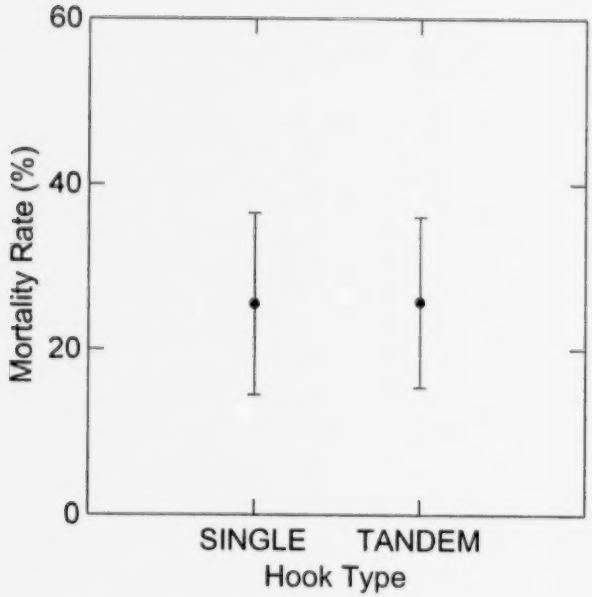

Figure 4. Mean short-term (0-24hr) mortality rates for coho caught on single barbless and tandem barbless hook cut-plug herring (with 95% confidence interval).

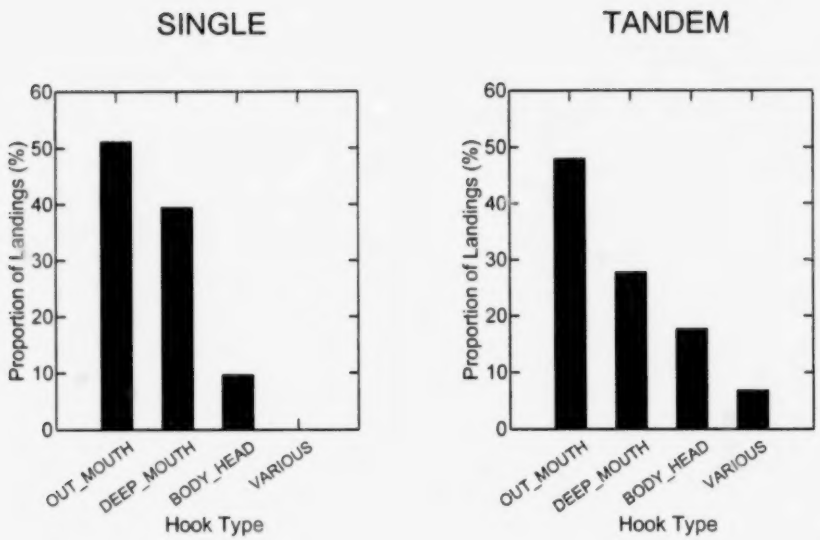

Figure 5. Location of hooks in the landings for coho caught on single barbless hook and tandem barbless hook cut-plug herring.

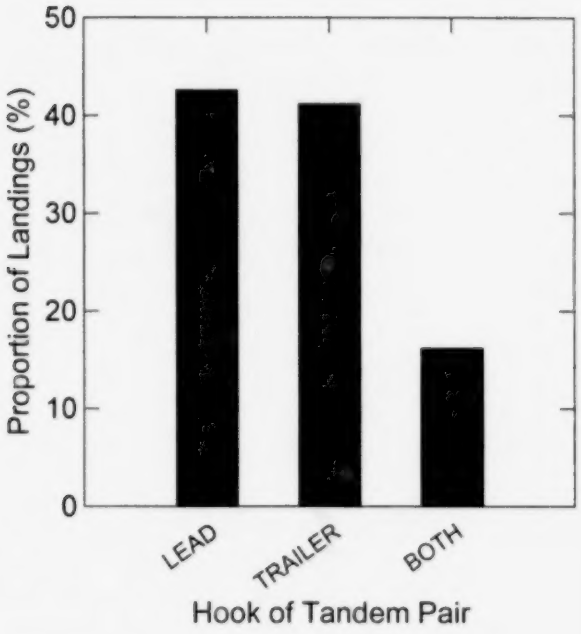

Figure 6. Proportion of landings involving the lead, trailing, or both hooks of the tandem barbless hook pair.

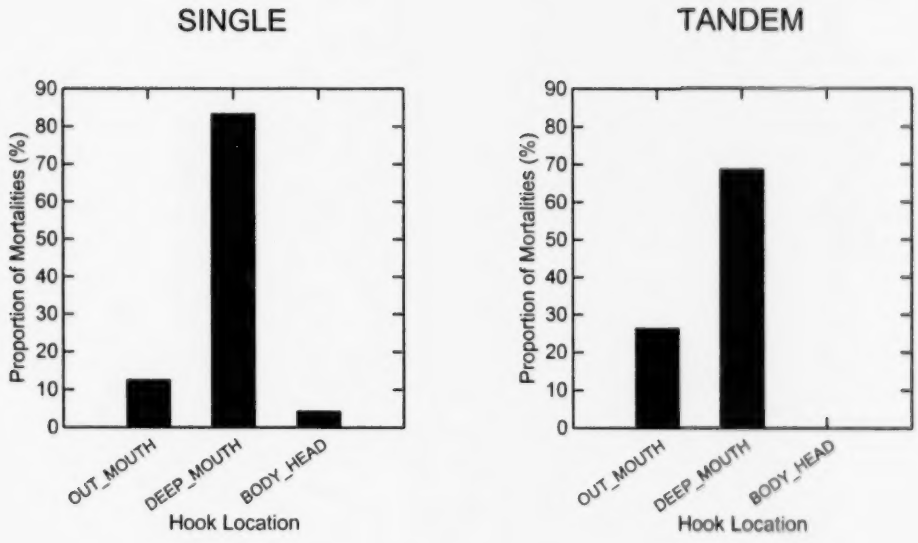

Figure 7. Location of hooks in the mortalities for coho caught on single barbless hook and tandem barbless hook cut-plug herring.

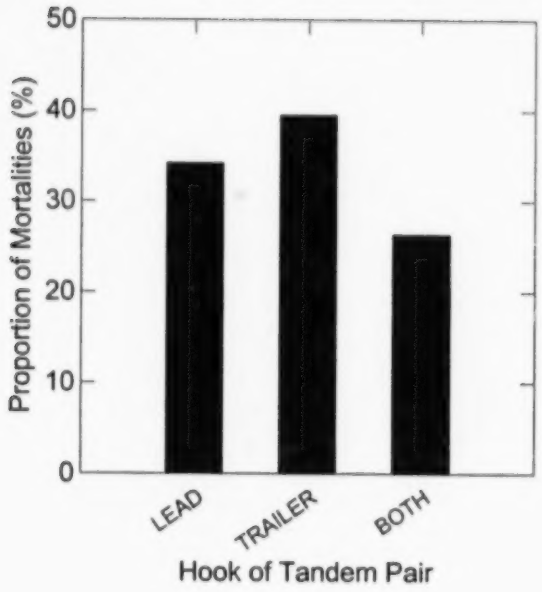

Figure 8. Proportion of mortalities involving the lead, trailing, or both hooks of the tandem barbless hook pair.

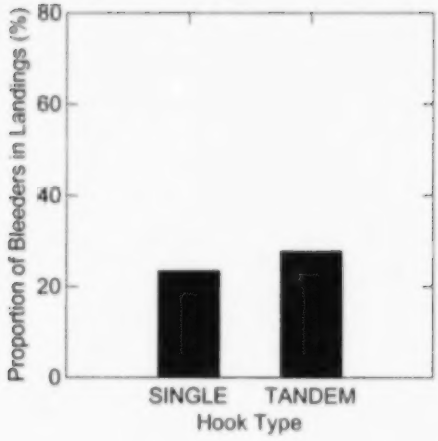

Figure 9. Bleeding rates in the landings for coho caught on single barbless hook and tandem barbless hook cut-plug herring.

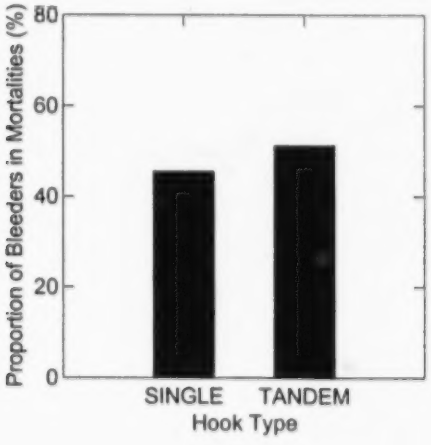

Figure 10. Bleeding rates in the mortalities for coho caught on single barbless hook and tandem barbless hook cut-plug herring.